New Champlain Bridge Corridor Project

Design Basis Report: SLR

Concept Design Stage

181201-20000-43EB-000002
REV.PB

Prepared For:

Canada

Date:

December 10, 2015

ATIA - 19(1)

Revision	Change Description and Reason	Date
PA	Issued for Review	2015-11-20
PB	Issued for Review	2015-12-10

Prepared by: [redacted]

Reviewed by:

Approved by:

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PROJECT TITLE: NEW CHAMPLAIN BRIDGE CORRIDOR PROJECT

DOCUMENT TITLE: SLR - *Concept Design Stage*

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Annex A List of drawings

1. SLR CONCEPTUAL DESIGN REPORT

Objective

This report address the study of two alternative alignments for an SLR system that extend from the eastern Permanent Project Limits at Brossard to the island of Montreal. It answers the requirements as detailed in schedule 7, part 12, "PROVISION FOR TRANSIT", article 3.3.2 "SLR conceptual design"

Project Specific Inputs

Critères de performance et d'exploitation associés à l'implantation d'un système de transport collectif dans le corridor du nouveau pont pour le Saint Laurent, 210-1001-25-01-00D (R07) dated 2015-02-07 from AMT.

1.1. Standards (REFERENCES)

1.1.1. Codes and Specifications

As referenced by clause 2 of schedule 7 part 12 (Provision for transit), the following standards have been considered for the design are not placed in order of precedence:

A. AREMA Manual for Railway Engineering;

B. AREMA Communications & Signal Manual;

C. NFPA 130 Standard for Fixed Guideway Transit & Passenger Rail Systems;

D. NFPA 502 Standard for Road Tunnels, Bridges, and Other Limited Access Highways;

E. NFPA 70, National Electrical Code;

F. National Electrical Code of Canada;

G. National Fire Code of Canada;

H. National Building Code of Canada;

I. CAN/CSA B651.M90 Barrier-Free Design

J. Track Design handbook for Light Rail Transit; TCRP Report 155, Transit Cooperative Research Program Sponsored by the Federal Transit Administration.

The units system used is the SI system (metric).

1.2. General design requirements

1.2.1. Design train

A. Static width: 3.2m;

B. Length car: 20m; and

C. Height: 3.9m from the top of rail excluding the height associated with a pantograph.

D. Six cars per train with a total length of 120m;

E. Maximum capacity of 900 passengers (seated and standing); and

F. Accessible to persons with reduced mobility.

1.2.2. Clearances and typical sections

1.2.2.1. CLEARANCES

Unless noted otherwise, the Transit Corridor for SLR shall comprise two SLR tracks and shall have a minimum functional width of 10.0m between the inside faces of the adjacent barriers.

The width of the dynamic profile of maximum movement shall be taken as 4.0m.

1.2.2.2. TRAIN OPERATIONS

The maximum line speed shall be taken as 100km/h.

The maximum permitted vehicle speed shall be taken as 100km/h.

The design speed shall be taken as 120 km/h.

The Private Partners shall assume 138,000 trains per year in each direction.

The headway between trains (peak demand) shall be taken as 90 seconds.

1.2.2.3. TRACK SYSTEM

The horizontal alignment shall comply with the following:

A. minimum radius of curvature without superelevation shall be 1500m;

B. minimum radius of curvature with superelevation shall be 200m;

C. maximum super elevation shall be 160mm;

D. minimum length of spiral shall be 30m;

E. minimum tangent between two spirals shall be 40m.

The vertical alignment shall comply with the following:

F. maximum allowable grade shall be taken as 4%;

G. minimum allowable grade shall be 0.5% with the exception of the future IdS SLR station;

H. minimum length of vertical curvature shall be 100m;

I. minimum tangent between two vertical curves shall be 40m.

1.2.2.4. TRACK CHARACTERISTICS

Characteristics of the tracks are:

J. Type 115 RE rails;
K. Tracks will be standard gage, 1435 mm;
L. CWR will be used for the project, containment rails (Jordan rail) will be used;
Rails will be installed on concrete plinths.

2. VERTICAL AND HORIZONTAL SLR TRACK PROFILES-ALTERNATE ALIGNMENTS

Two alternate alignments were studied.

In the first alternate alignment, there are two options, option 1 and option 2.

Option 1 is in the middle of the two IdS bridges and dives as it reaches the Montréal Island.

In option 2, east of the new P-10 B structure, the profile goes up and crosses the A-15 WB to go in an north-east direction.

In the second alternate alignment, option 3, the profile goes up west of the SLR station, and crosses the A-15 WB to find an alignment alongside and south of the causeway.

The general layout of the 3 options is shown on drawing SK-H-01.

The details of option 1 are shown on drawings SK-H-02 to SK-H-07.

The details of option 2 are shown on drawings SK-H-08 to SK-H-12.

The details of option 3 are shown on drawings SK-H-13 to SK-H15.

For all these option, the SLR station is located at the same stationing.

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2.2. 2nd Alternate alignment option 3 (Causeway)

[redacted]

[redacted]

3. SLR STATION

The station is located between station 34+953 and 35+088, as required in the PA. A central platform, 135 meters in length, is considered in the design.:

0.20 m : air gap between a fixed object and the dynamic profile;

2.00 m : dynamic profile of maximum movement to the centre of track;

1.50 m : distance from the center of track to the edge of the platform;

13m : width of the platform within the required 20.8 m

The platform has a profile of 0.0%

[redacted]

Drawings SK-ST-01 to SK-ST-06 and SK-A-01 to SK-A-03 give the details of the SLR station.

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6. RAILWAY SYSTEM PLAN

The railway system plan is shown on SK-H-01 to SK-H-14 and SK-XS-01 and SK-XS-02.

[redacted]

[redacted]

Drawings

The proposed SLR the proposed alignment and profile of option 1 are shown are shown on drawings SK-H-02 to SK-H-07.

Details of the structures are shown on SK-ST-07 to SK-ST-09.

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[redacted]

Drawings

The proposed SLR the proposed alignment and profile of option 2 are shown are shown on drawings SK-H-08 to SK-H-12.

Details of the structures are shown on SK-ST-10 to SK-ST-13

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Drawings

The proposed SLR the proposed alignment and profile of option 3 are shown are shown on drawings SK-H-13 to SK-H-15.

Details of the structures are shown on SK-ST-14 to SK-ST-15.

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13. DETAILED SUPERSTRUCTURE CROSS SECTION OF THE NBSL

CLEARANCES AND ENVELOPES

[redacted]

CLEARANCES UNDER THE BRIDGE MST

[redacted]

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PLINTH ANCHORING

[redacted]

CABLE TRAYS AND WALKWAYS

[redacted]

FUTURE DESIGN AND CONSTRUCTION

[redacted]

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14. SLR EXPANSION JOINTS ON THE NBSL

EXPANSION JOINTS

[redacted]

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15. SCHEDULE OF ALL NON-STRUCTURAL ITEMS REQUIRED ON THE NBSL

[redacted]

16. LOCATION AND GENRERAL ARRANGEMENT OF OTHER REQUIRED STRUCTURES

[redacted]

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17. PROCEDURE TO CORRECT THE GEOMETRY OF THE NBSL

[redacted]

18. TEMPORARY TRAFFIC MANAGEMENT

[redacted]

Option 1

[redacted]

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[redacted]

Option 2

[redacted]

Option 3

[redacted]

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[redacted]

19. SLR EMERGENCY EVACUATION PLAN FOR NBSL

[redacted]

20. SLR MAINTENANCE PLAN FOR NBSL

To be completed by OMR

21. PROPOSED ARRAGEMENTS FOR ACCESS TO THE OMR INFRASTRUCTURE

To be completed by OMR

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23. PRELIMINARY TRAIN FIRE ANALYSIS AS PER NFPA 502

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Annex A

List of drawings

HIGHWAY

[redacted]

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ARCHITECTURAL DRAWINGS

SK-A-01 SLR Station plan view

SK-A-02 SLR Station plan view and sections

SK-A-03 Sketches

New Champlain Bridge Corridor Project

Design Report: SLR

Conceptual Design Report

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Prepared For:

Canada

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APRIL 25, 2016

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PA	Initial submission	2015-11-20
PB	Revision	2015-12-10
PC	Revision	2016-04-13
PD	Revision	2016-04-25

Prepared by: [redacted]

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Approved by:

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PROJECT TITLE: NEW CHAMPLAIN BRIDGE CORRIDOR PROJECT

DOCUMENT TITLE: SLR Conceptual Design Report

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Annex A List of drawings

1. SLR CONCEPTUAL DESIGN REPORT

Objective

This report treats the feasibility of an SLR between Brossard and Montréal using the transit corridor on the New Bridge on the St-Lawrence (NBSL).

The report covers the study of two alternative alignments, as detailed in schedule 7, part 12, "PROVISION FOR TRANSIT", article 3.3.2 "SLR conceptual design",

This report provides additional details on the SLR conceptual design and should be read in parallel with the SLR set of sketches.

Project Specific Inputs

Critères de performance et d'exploitation associés à l'implantation d'un système de transport collectif dans le corridor du nouveau pont pour le Saint Laurent, 210-1001-25-01-00D (R07) dated 2015-02-17 from AMT.

1.1. Standards (REFERENCES)

1.1.1. Codes and Specifications

As referenced by clause 2 of schedule 7 part 12 (Provision for transit), the following standards have been considered for the design are not placed in order of precedence:

A. AREMA Manual for Railway Engineering;

B. AREMA Communications & Signal Manual;

C. NFPA 130 Standard for Fixed Guideway Transit & Passenger Rail Systems;

D. NFPA 502 Standard for Road Tunnels, Bridges, and Other Limited Access Highways;

E. NFPA 70, National Electrical Code;

F. National Electrical Code of Canada;

G. National Fire Code of Canada;

H. National Building Code of Canada;

I. CAN/CSA B651.M90 Barrier-Free Design

J. Track Design handbook for Light Rail Transit; TCRP Report 155, Transit Cooperative Research Program Sponsored by the Federal Transit Administration.

The units system used is the SI system (metric).

1.2. General design requirement

1.2.1. Design train

A. Static width: 3.2m;

B. Length car: 20m; and

C. Height: 3.9m from the top of rail excluding the height associated with a pantograph.

D. Six cars per train with a total length of 120m;

E. Maximum capacity of 900 passengers (seated and standing); and

F. Accessible to persons with reduced mobility.

1.2.2. Clearances and typical sections

1.2.2.1. CLEARANCES

Unless noted otherwise, the Transit Corridor for SLR shall comprise two SLR tracks and shall have a minimum functional width of 10.0m between the inside faces of the adjacent barriers.

The width of the dynamic profile of maximum movement shall be taken as 4.0m.

Clearances are as folllows :

At Infrastructure type	Minimum vertical clearance
Above highways	5.1 m
Railways and SLR (Over rails)	7.3 m
MUP	3 m
SANEXEN access road	4.5 m
Clearance above navigation channel	Elev. :14.88 m

1.2.2.2. TRAIN OPERATIONS

The maximum line speed shall be taken as 100km/h.

The maximum permitted vehicle speed shall be taken as 100km/h.

The design speed shall be taken as 120 km/h, with exceptions of 80 km/h for option 1 and 70km/h for option 2 and 3 for tight curves between Ile des Sœurs and Montreal as well as for the approach to the station.

The Private Partners shall assume 138,000 trains per year in each direction.

The headway between trains (peak demand) shall be taken as 90 seconds.

1.2.2.3. TRACK SYSTEM

The horizontal alignment shall comply with the following:

A. minimum radius of curvature without superelevation shall be 1500m;

B. minimum radius of curvature with superelevation shall be 200m;

C. maximum super elevation shall be 160mm;

D. minimum length of spiral shall be 30m;

E. minimum tangent between two spirals shall be 40m, excepted for the east approach to the station.

The vertical alignment shall comply with the following:

F. maximum allowable grade shall be taken as 4%, excepted for option 1B of alternative 1, which is 5.7%;

G. minimum allowable grade shall be 0.5% with the exception of the future IdS SLR station;

H. minimum length of vertical curvature shall be 100m;

I. minimum tangent between two vertical curves shall be 40m.

1.2.2.4. TRACK CHARACTERISTICS

Characteristics of the tracks are:

J. Type 115 RE rails;

K. Tracks will be standard gage, 1435 mm;

L. CWR will be used for the project, containment rails (Jordan rail) will be used; Rails will be installed on concrete plinths.

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2. VERTICAL AND HORIZONTAL SLR TRACK PROFILES-ALTERNATE ALIGNMENTS

In this conceptual design, two alternate alignments were studied. In the first alternate alignment, there are two options, option 1 and option 2.

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[redacted]

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Compliance

The following code analysis has been prepared to comply with the National Buiding Code of Quebec 2015.

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6. RAILWAY SYSTEM PLAN

[redacted]

SNC·LAVALIN MMM GROUP

SIGNATURE ON THE SAINT LAWRENCE

7. [redacted]

[redacted]

Drawings

The proposed SLR alignment and profile of option 1 are shown are shown on drawings SK-H-02 to SK-H-14.

Details of the structures are shown on SK-ST-07 to SK-ST-09.

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9. [redacted]

[redacted]

Drawings

The proposed SLR the proposed alignment and profile of option 2 are shown are shown on drawings SK-H-15 to SK-H-18.

Details of the structures are shown on SK-ST-10 to SK-ST-13

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[redacted]

Drawings

The proposed SLR the proposed alignment and profile of option 3 are shown are shown on drawings SK-H-19 to SK-H-215.

Details of the structures are shown on SK-ST-14 to SK-ST-15.

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For details, see sketch, SK-XS 01.

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25. INTERFACES BETWEEN THE DBOMR INFRASTRUCTURE AND THE POSSIBLE FUTURE SLR INFRASTRUCTURE

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Annex A

List of drawings

HIGHWAY

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DBOMR

OPTION 1

SK-DB-01 and SK-DB-02 Plans

OPTION 2

SK-DB-03 and SK-DB-04 Plans

OPTION 3

SK-DB-5 Plans

[redacted]

SK-DB-06 and SK-DB-07 Plans

OTHER DRAWINGS

SK-XC-01 [redacted]

SK-XC-02

SK-EJ-01

ARCHITECTURAL DRAWINGS

SK-A-01 SLR Station plan view

SK-A-02 SLR Station plan view and sections

SK-A-03 Sketches

New Champlain Bridge Corridor Project

Design Report: SLR

Conceptual Design Report

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Prepared for:

Canada

Date:

July 28, 2017

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PA	Initial submission	2015-11-20
PB	Revision	2015-12-10
PC	Revision	2016-04-13
PD	Revision	2016-04-25
PE	Revision	2016-07-11
PF	Revision	2017-05-15
PG	Revision	2017-07-28

Prepared by: [redacted]

Reviewed by:

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1.1.1. Codes and Specifications

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B. AREMA Communications & Signal Manual;

C. NFPA 130 Standard for Fixed Guideway Transit & Passenger Rail Systems;

D. NFPA 502 Standard for Road Tunnels, Bridges, and Other Limited Access Highways;

E. NFPA 70, National Electrical Code;

F. National Electrical Code of Canada;

G. National Fire Code of Canada;

H. National Building Code of Canada;

I. CAN/CSA B651.M90 Barrier-Free Design;

J. Track Design handbook for Light Rail Transit; TCRP Report 155, Transit Cooperative Research Program Sponsored by the Federal Transit Administration.

The units system used is the SI system (metric).

1.2. General Design Requirement

1.2.1. Design Train

A. Static width: 3.2 m;

B. Length car: 20 m;

C. Height: 3.9 m from the top of rail excluding the height associated with a pantograph;

D. Six cars per train with a total length of 120 m;

E. Maximum capacity of 900 passengers (seated and standing) and

F. Accessible to persons with reduced mobility.

1.2.2. Clearances and Typical Sections

1.2.2.1. CLEARANCES

Unless noted otherwise, the Transit Corridor for SLR shall comprise two SLR tracks and shall have a minimum functional width of 10.0 m between the inside faces of the adjacent fences and barriers.

The width of the dynamic profile of maximum movement shall be taken as 4.0m.

Clearances are as follows:

Infrastructure type	**Minimum vertical clearance**
Above highways	5.1 m
Railways and SLR (Over rails)	7.3 m
MUP (Multiple Users Passage)	3 m
SANEXEN access road	4.5 m
Clearance above navigation channel	Elev. : 14.88 m

1.2.2.2. TRAIN OPERATIONS

The maximum line speed shall be taken as 100 km/h.

The maximum permitted vehicle speed shall be taken as 100 km/h.

The design speed shall be taken as 120 km/h, with exceptions of 80 km/h for option 1 and 75 km/h for option 2 and 3 for tight curves between Île-des-Sœurs and Montreal as well as for the approach to the station.

The Private Partner shall assume 138,000 trains per year in each direction.

The headway between trains (peak demand) shall be taken as 90 seconds.

1.2.2.3. TRACK SYSTEM

The horizontal alignment shall comply with the following:

A. minimum radius of curvature without superelevation shall be 1500 m;

B. minimum radius of curvature with superelevation shall be 200 m;

C. maximum super elevation shall be 160 mm;

D. minimum length of spiral shall be 30 m;

E. minimum tangent between two spirals shall be 40 m, excepted for the east approach to the station where section 3.2.7 of the TCRP applies.

The vertical alignment shall comply with the following:

F. maximum allowable grade shall be taken as 4%, excepted for option 1B of alternative 1, which is 5.7%;

G. minimum allowable grade shall be 0.5% with the exception of the future Île-des-Sœurs SLR station where the tracks are level;

H. minimum length of vertical curvature shall be 100 m;

I. minimum tangent between two vertical curves shall be 40 m.

1.2.2.4. TRACK CHARACTERISTICS

Characteristics of the tracks are:

J. Rail section 115 RE;
K. Tracks will be standard gage, 1435 mm;
L. Continuous Welded Rail (CWR) will be used for the project, containment rails (Jordan rail) will be used;

Rails will be installed on concrete plinths.

2. VERTICAL AND HORIZONTAL SLR TRACK PROFILES – ALTERNATE ALIGNMENTS

In this conceptual design, two alternate alignments were studied. In the first alternate alignment, there are two options, Option 1 and Option 2.

[redacted]

Track alignment from station 5+100 to the east limit of the project is the same for all options and is shown on SK-H-06 to SK-H-14.

For all these options, the SLR station is located at the same stationing.

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6. RAILWAY SYSTEM PLAN

The railway system plan is shown on SK-H-01 to SK-H-14 and SK-XS-01 and SK-XS-02.

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For details, see sketch, SK-XS 01.

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Annex A

List of drawings

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DBOMR

OPTION 1

SK-DB-01 and SK-DB-02 Plans

OPTION 2

SK-DB-03 and SK-DB-04 Plans

OPTION 3

SK-DB-5 Plans

[redacted]

SK-DB-06 and SK-DB-07 Plans

OTHER DRAWINGS

SK-XC-01 [redacted]

SK-XC-02

SK-EJ-01

ARCHITECTURAL DRAWINGS

SK-A-01 SLR Station plan view

SK-A-02 SLR Station plan view and sections

SK-A-03 Sketches

Annex B

Temporary traffic management sketches

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Technical Paper

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1.0 CONTEXT

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New Champlain Bridge Corridor Project

Design Report: SLR

Issue for Design

181201-21510-43EB-000002
REV. 00

Prepared for:

Canada

Date:

May, 02 2018

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Revision	Change Description and Reason	Date
00	Issue for design	2018-05-02

Prepared by: [redacted]

Reviewed by:

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PROJECT TITLE: NEW CHAMPLAIN BRIDGE CORRIDOR PROJECT

DOCUMENT TITLE: SLR Conceptual Design Report

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TABLE OF CONTENTS

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1. SLR CONCEPTUAL DESIGN REPORT

Objective

This report treats the feasibility of an SLR between Brossard and Montreal using the transit corridor on the New Bridge on the St-Lawrence (NBSL).

The report covers the study of two alternative alignments, as detailed in schedule 7, part 12, "PROVISION FOR TRANSIT", article 3.3.2 "SLR conceptual design.

This report provides additional details on the SLR conceptual design and should be read in parallel with the SLR set of sketches.

Project Specific Inputs

« *Critères de performance et d'exploitation associés à l'implantation d'un système de transport collectif dans le corridor du nouveau pont pour le Saint Laurent, 210-1001-25-01-00D (R07)* » dated 2015-02-17 from AMT.

1.1. Standards (REFERENCES)

1.1.1. Codes and Specifications

As referenced by clause 2 of schedule 7 part 12 (Provision for transit), the following standards have been considered for the design, and are listed in no particular order of precedence:

A. AREMA Manual for Railway Engineering;

B. AREMA Communications & Signal Manual;

C. NFPA 130 Standard for Fixed Guideway Transit & Passenger Rail Systems;

D. NFPA 502 Standard for Road Tunnels, Bridges, and Other Limited Access Highways;

E. NFPA 70, National Electrical Code;

F. National Electrical Code of Canada;

G. National Fire Code of Canada;

H. National Building Code of Canada;

I. CAN/CSA B651.M90 Barrier-Free Design;

J. Track Design handbook for Light Rail Transit; TCRP Report 155, Transit Cooperative Research Program Sponsored by the Federal Transit Administration.

The units system used is the SI system (metric).

1.2. General Design Requirement

1.2.1. Design Train

A. Static width: 3.2 m;

B. Length car: 20 m;

C. Height: 3.9 m from the top of rail excluding the height associated with a pantograph;

D. Six cars per train with a total length of 120 m;

E. Maximum capacity of 900 passengers (seated and standing) and

F. Accessible to persons with reduced mobility.

1.2.2. Clearances and Typical Sections

1.2.2.1. CLEARANCES

Unless noted otherwise, the Transit Corridor for SLR shall comprise two SLR tracks and shall have a minimum functional width of 10.0 m between the inside faces of the adjacent fences and barriers.

The width of the dynamic profile of maximum movement shall be taken as 4.0m.

Clearances are as follows:

Infrastructure type	Minimum vertical clearance
Above highways	5.1 m
Railways and SLR (Over rails)	7.3 m
MUP (Multiple Use Path)	3 m
SANEXEN access road	4.5 m
Clearance above navigation channel	Elev. : 14.88 m

1.2.2.2. TRAIN OPERATIONS

The maximum line speed shall be taken as 100 km/h.

The maximum permitted vehicle speed shall be taken as 100 km/h.

The design speed shall be taken as 120 km/h, with exceptions of 80 km/h for option 1 and 75 km/h for option 2 and 3 for tight curves between Île-des-Sœurs and Montreal as well as for the approach to the station.

The Private Partner shall assume 138,000 trains per year in each direction.

The headway between trains (peak demand) shall be taken as 90 seconds.

1.2.2.3. TRACK SYSTEM

The horizontal alignment shall comply with the following:

A. minimum radius of curvature without superelevation shall be 1500 m;

B. minimum radius of curvature with superelevation shall be 200 m;

C. maximum super elevation shall be 160 mm;

D. minimum length of spiral shall be 30 m;

E. minimum tangent between two spirals shall be 40 m, excepted for the east approach to the station where section 3.2.7 of the TCRP applies.

The vertical alignment shall comply with the following:

F. maximum allowable grade shall be taken as 4%, excepted for option 1B of alternative 1, which is 5.7%;

G. minimum allowable grade shall be 0.5% with the exception of the future Île-des-Sœurs SLR station where the tracks are level;

H. minimum length of vertical curvature shall be 100 m;

I. minimum tangent between two vertical curves shall be 40 m.

1.2.2.4. TRACK CHARACTERISTICS

Characteristics of the tracks are:

J. Rail section 115 RE;
K. Tracks will be standard gage, 1435 mm;
L. Continuous Welded Rail (CWR) will be used for the project, containment rails (Jordan rail) will be used;

Rails will be installed on concrete plinths.

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Drawings

The proposed SLR alignment and profile of option 1 are shown are shown on drawings SK-H-02 to SK-H-14.

Details of the structures are shown on SK-ST-07 to SK-ST-09.

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Drawings

The proposed SLR the proposed alignment and profile of option 2 are shown are shown on drawings SK-H-15 to SK-H-18.

Details of the structures are shown on SK-ST-10 to SK-ST-13

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Drawings

The proposed SLR the proposed alignment and profile of option 3 are shown are shown on drawings SK-H-19 to SK-H-215.

Details of the structures are shown on SK-ST-14 to SK-ST-15.

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Annex A

List of drawings

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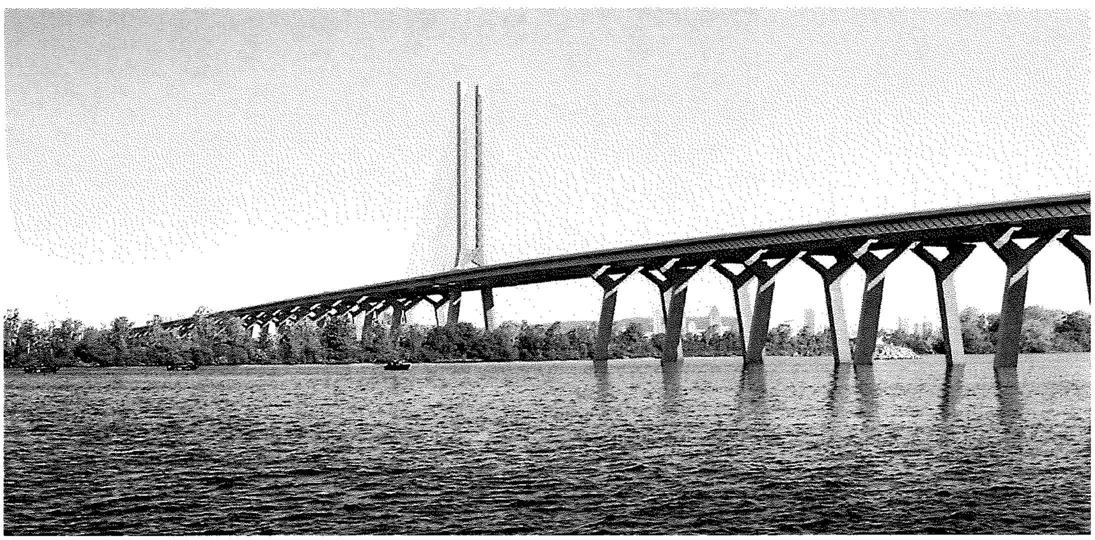
Annex B

Cable-Stayed Bridge

New Champlain Bridge Corridor Project

Rail-Structure Interaction Report
Cable-Stayed Bridge



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Canada

Date:

June 17, 2016

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International Bridge Technologies

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1. Introduction

This report describes the rail-structure interaction analysis of the Cable Stayed Main Span of the New Bridge for the Saint Lawrence (NBSL). The analysis technique and modeling of the various components of the structure are described. [redacted]

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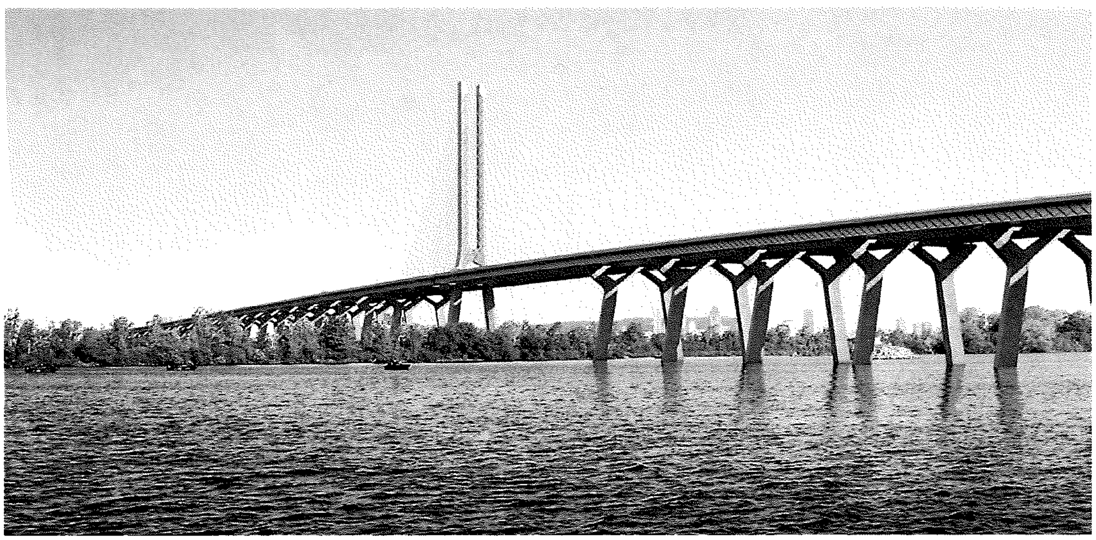
Annex C

Rail-Structure Interaction

New Champlain Bridge Corridor Project

SLR Conceptual Design Report Annex: Rail-Structure Interaction



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1. Introduction

This report is an annex to the SLR Conceptual Design Report (181201-20000-43EB-000002_REVPD). It consists in a supplement to the design reports provided along with all Transit Corridor super structures of the New Bridge on the Saint Lawrence (Approaches and Cable Stayed Bridge).

The goal of this document is to provide a general overview of the checks which have been completed to address rail-structure interaction. The report also provides a summary of the design assumptions used for the track work elements of the Light Rail Transit system.

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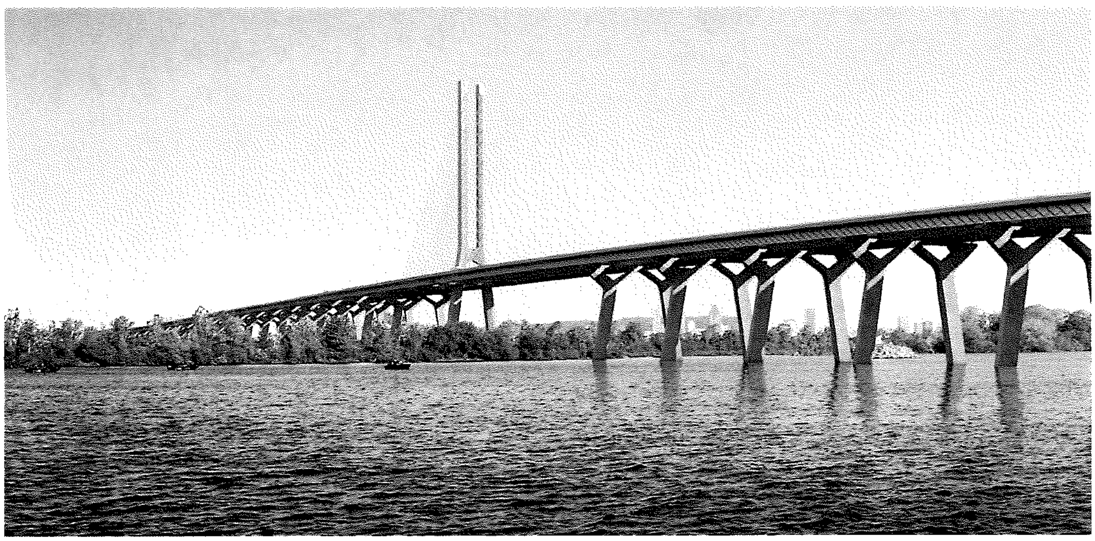
Annex D

Approaches

New Champlain Bridge Corridor Project

Rail Structure Interaction Report
Approaches



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2. Introduction

As required by the Project Agreement (PA) Schedule7/Part7, the followings analysis, specific to the SLR phase, have been carried out for the NBSL Transit Corridor Approaches and are described in the present report:

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181201
New Champlain Bridge Corridor Project

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Purchase Order/Contract No. and Title:	
VDR Codes:	
Localization:	
Drawing Reference:	
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ATIA - 19(1)

FROM:

[redacted]

TO:
Pierre Bolduc, ing.
Senior Engineer – New Champlain Bridge
Infrastructure Canada

DATE: May 15, 2017

RE: Light Rail Transit – Stray Currents, requirements for the new Champlain Bridge

INTRODUCTION

The selected power distribution for the new "Réseau électrique de Montreal" (REM) light rail system has been proposed to be a 1500 Volts Direct Current (DC) system using a catenary distribution where the rails are used as the primary current return to the power supply (source).

This type of power distribution system is considered reliable and well suited for low speed rail applications. A DC power distribution system for transit applications is subject to stray currents leaking into the underlying infrastructure and may cause premature corrosion to metallic conduits or structures depending on the path used by the stray currents to return to the power source. Particular to REM, it will be using the Transit Corridor on the New Champlain Bridge (NCB), a structure that has a 125 years design life.

This type of installation is widely used throughout the world and does not represent a high risk as long as the appropriate design criteria are established. There are many references, papers, codes and standards available in addition to design criteria references published for similar installations and available for general public consultation.

SUMMARY

Prior to engaging the design for the REM light rail system, it is recommended that the Relevant Authority has a valid design criteria and specifications reference established and approved. This reference should be prepared by an independent organization from the design-build team and be used as contractual terms for the award and execution of the project.

The following design factors are general considerations for a LRT design regarding stray currents and illustrate proven methods to eliminate, mitigate or control stay currents which can cause costly infrastructure deterioration due to corrosion. The design shall include both primary and secondary protective systems. The secondary measures are coupled with primary solutions in the event that these become ineffective at locations where excessive rail leakage occurs.

DESIGN CONSIDERATIONS

- **<u>DC power supply design (substation);</u>**
  There are many factors involved in designing a group of AC to DC power substations required to supply power to an overhead contact system (OCS) used in transit power distribution. Grounding (separate AC and DC ground mats), lightning and overvoltage protection, fault protection, along with many other criteria required by code shall be included in the design. The design shall also include the proper equipment used for stray current monitoring. A common method requires the use of a shunt bolted between the DC bus and the DC ground conductor and using a diode to control the negative return. This will allow most of the stray currents to be collected and returned through the diode. This shunt circuit is used to **monitor and record stray currents** collected at the substation. A data acquisition system shall be included to record stray current activities over time, it is essential to analyse the effectiveness of the stray current mitigation solutions.

- **<u>Bonding (low resistance return circuit)</u>**;
  The rails being the primary return circuit for the current used in the LRT traction system, they shall be installed and assembled such that the total resistance of the rails is <u>as low as possible</u> (*see note 1 below*). Basic methods to increase conductivity include the selection of rail material and size, welding rails at junctions, using redundant jumpers (rail bonds) welded to the rails for discontinuous rail junctions such as rail expansion areas, and cross bonding rails with cables to maintain equal potential on all rails. The installation of a dedicated and properly sized insulated DC ground conductor used to interconnect the rails at regular intervals and connected to the substation negative return circuit shall provide a redundant path (drain) for the current return to the power source. This common negative return bus shall provide solid continuity in the event that the rail system is affected by a technical failure (broken rail, cracked weld, broken jumper cable or connection).

  <u>NOTE 1</u>
  The resistance value is not prescribed since this parameter is determined by the resistivity of the rail or materials used and the total length of rails or conductors involved. Many design parameters such as the distance between power supply stations and the maximum allowable touch voltage (70 volts or less) for the rails will influence the final result. The design model and power simulations shall provide the final reference values.

- **<u>High resistance of track to earth potential;</u>**
  The insulation of rails (trackwork) is one of the primary design factors in preventing stray currents to the underlying infrastructure. Setting the tracks on a plinth system requires that the plinth concrete be of higher resistance and insulated materials be used to increase the track to substructure resistance. Using special concrete mix, insulated anchors, coated fasteners will contribute to providing proper insulation.

- **Water drainage and track cleanliness;**
  Keeping the tracks clean and avoiding water accumulation are critical to preventing conductive paths which can develop between the rail system and the substructure. An elevated rail support such as a plinth makes this task easier. Special design considerations are required where the rails are recessed or encased below surface in areas such as vehicle or pedestrian crossings or stations. Drainage, periodic cleaning and specific insulating materials are necessary to prevent conductive paths from developing between the rails and the surrounding infrastructure grounding. A properly drained and clean track ballast (trackbed) is also important.

- **Third rail design (DC current return path);**
  Some rail systems make use of an insulated and continuous third rail ground system which ensures a solid return circuit. This solution is more often applied to existing railwork where the task of insulating and bonding may be too difficult or costly. The application of a third rail offers advantages which shall not be ignored and included in the design evaluation if applicable.

- **Solid return path to DC power source of stray currents;**
  Although the function of the primary solutions is to prevent stray currents from flowing into the infrastructure, it is almost impossible to eliminate all the conditions where these stray currents may develop and become a risk to the integrity of metallic components located inside or near the infrastructure. Solutions exist such as the implementation of a separate grounded collector pad located immediately below the track system and isolated from the structural ground grid. This approach is used to collect any stray currents and return them to a dedicated drain conductor. It is critical to isolate the LRT electrical ground system from the NCB ground system (no bonding). Both civil and electrical design considerations are applicable to achieve proper isolation. The armature in the concrete supports (plinths) for the rails combined with an insulated segregated ground wire (drain) shall be designed for such a purpose. When installing the plinth anchors to the NCB deck surface, the design shall make use of dielectric material (non-conductive or high resistance values) to create a high resistance barrier which will prevent stray currents from migrating to the NCB deck infrastructure.

- **Study (inventory) of all utilities in proximity of rail system;**
  In the risk assessment for corrosion prevention, a complete inventory of all utilities in close proximity of the rail system shall be compiled and all risks shall be assessed for potential corrosion damage. Solutions exist to mitigate the risks of stray currents having a negative impact on the utilities and shall be applied based on the inventory and assessment. These may include the use of non-conductive conduits (or insulating components) in substitution of metallic components in order insulate the utilities such that any potential stray currents do not collect or dissipate through them. Risks are greater near power supply stations where stray currents collect upon returning to the source.

- **Cathodic protection for critical areas or utilities;**
  When critical utilities are considered at risk and the presence of stray currents cannot

be eliminated or mitigated, applying proven cathodic protection solutions, to supplement stray current management, shall be provided to help protect the components from potential premature corrosion. These critical areas shall be identified and included in the risk assessment study.

- **DC magnetic fields and EMI;**
  A continuous steady-state condition of DC power distribution does not generate or induce currents in nearby metallic structures or ground. Only when transients are present on the DC supplied OCS can some currents be developed. The impact of EMI on stray currents is limited to earth-leakage caused by transients in the system and the risk is greater as the load (train) gets further from the source. The power system design and modeling shall provide a complete analysis of the impact of transients to the surrounding infrastructure and include the risks involving electromagnetic interferences (EMI) and earth leakage.

- **Crossings and switching devices (if applicable);**
  When designing a rail network containing crossings for pedestrians and vehicles or rail switching devices, care must be taken to maintain the integrity of the track to earth high resistance value.

MONITORING OF STRAY CURRENTS (LEAKAGE)

- **Monitoring;**
  The REM project for a LRT system shall include the design for selection and operation of a proven and effective monitoring and data acquisition system. This is the only way to ensure that excessive stray currents do not develop over time and to ensure the durability and protection of the NCB infrastructure. A similar system will be provided in the NCB infrastructure to monitor other conditions.

- **Commissioning and testing;**
  Once installed, the monitoring and measurement of stray current values shall be included in the commissioning plan. Using an operational train, the real-time measurements shall be analyzed and compared with the actual position of the train on the rail system. The data set shall then be used to identify weak areas prone to stray currents and under which operational conditions. Corrective actions shall be required if the measured stray current levels are considered excessive by comparison to the remaining data profile.

- **Alarms on calibrated deviations;**
  With proper benchmarking of measured stray currents, the results shall be used to calibrate the alarm trigger values used to identify when stray currents have exceeded a nominal threshold defined using the initial commissioning data profile or agreed with the NCB Authority.

- **Fault Finding and Problem Fixing;**
  The biggest challenge when non critical conditions are identified is the reaction time and priority set by the operating and maintaining Authority. The root cause of the faults are sometimes difficult to assess, testing procedures along with operational downtime shall be required to isolate the problems.

  The requirements for operational downtime are justified by the fact that:

  1) the risk of infrastructure degradation increases with time depending on the response time (tolerance) to address non-critical problems;
  and
  2) the NCB has a 125 years design life requirement.

MAINTAINING POWER SYSTEM AND PROTECTIVE EQUIPMENT

- **Preventive Maintenance and Inspections;**
  The long term reliability of the NCB requires that the LRT operation and maintenance plan shall require regular inspections of trackwork (insulators, jumpers, welds, etc.) and shall include inspection and testing of the integrity of the devices used to prevent stray currents including cathodic protection systems installed on utilities. The failure of the protective devices does not prevent the LRT from operating but shall require operational downtime as the risks of corrosion damage increase significantly and can eventually cause potential failure of critical utilities and NCB infrastructure. A complete maintenance plan is required and shall be submitted for approval. Copies of the Preventive Maintenance and Inspection Tasks and Reports shall be transmitted to the NCB Corridor Authority as per the approved maintenance schedule.

- **Track Cleaning;**
  One detail which is often neglected over time is the importance of maintaining track cleanliness and surroundings to prevent accumulation of conductive sediments which may breach the high resistance segregation between the traction ground grid and earth ground grid. The long term operation and maintenance plan shall have provision for periodic cleaning of the rails and be adjusted according to measured stray current values.

- **Performance Testing;**
  The integrity of the grounding system shall be tested regularly using very sensitive ground resistance measurement meters and probes. These measurements shall be performed at multiple locations along the LRT circuit and shall be compared to the benchmark values obtained at the commissioning stage. The reduction of conductivity values over time may increase potential stray current leakage.

- **Testing and calibration;**
  All electronic devices used to monitor or measure stray current activities or resistance values shall be calibrated and certified following the recommended frequency by the

manufacturer and be included in the maintenance plan.

CONCLUSION

The design of a new LRT for REM shall apply and respect the following general rules:

"The LRT DC system shall be designed and installed so as to ensure that there are no deliberate low resistance points of contact between the traction return circuit and the general mass of the earth or underlying infrastructure."

"The LRT DC system shall be operated and maintained so as to ensure that the performance and effectiveness of the methods designed to eliminate, mitigate or monitor stray currents remain in optimal operating conditions."

[redacted]

This document has been prepared based on standards, rules, guidelines and best practices available to the public regarding the risks associated with stray currents and their known effects on corrosion of adjacent infrastructure and utilities.